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THESIS

THE UNIFORM PRICE QUALITY ADJUSTED DISCOUNT AUCTION FOR AVIATION CONTINUATION PAY: POTENTIAL BENEFITS TO THE U.S. MARINE CORPS

by

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March 2010

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This objective of this thesis is to explore the potential benefits realized by the Marine Corps if the current Aviation Continuation Pay (ACP) system is replaced with an auction mechanism that utilizes Quality Adjusted Discount (QUAD) methodology. The Uniform Price Quality Adjusted Discount Auction is designed to reduce the total cost of ACP while simultaneously increasing the overall quality of the aviators being retained. The goal of this study was to evaluate the existing ACP system and through experimentation, coupled with economical analyses, determine the feasibility of replacing the current system of assigning the aviator retention bonus with one that incorporates QUAD methodology.

The QUAD auction mechanism caters to a wide range of individual reservation values resulting from various economic conditions. An ACP auction would reflect changing economic conditions, because aviators would reveal their true reservation values when bidding. Although an auction mechanism may not always result in a cost savings, it will ensure that the bonus amounts are set at the correct levels. If a QUAD auction were used in lieu of the current ACP system, Marine Corps manpower planners would have the flexibility to more cost effectively retain higher quality aviators while achieving Marine Corps aviator retention goals.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACIP   Aviation Career Incentive Pay

ACP   Aviation Continuation Pay

DoN   Department of the Navy

MCBUL   Marine Corps Bulletin

MOS   Military Occupational Specialty

QUAD   Quality Adjusted Discount

SRB   Selective Reenlistment Bonus

YCS   Years Commissioned Service

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I. INTRODUCTION

A. BACKGROUND

Military manpower planners have long had to contend with airlines in the civilian labor market to retain their highly trained pilots and naval flight officers. Until 2001, civilian airlines could lure highly desirable military pilots away from the military with promises of a better lifestyle, better benefits, a $300,000 salary, and a 14-day work month (Maue, 2008). To combat aviator shortages, Congress authorized the Aviation Continuation Pay (ACP) program in 1989 as a replacement to the Aviation Officer Continuation Pay program (GAO, 1994). The new ACP bonus was intended as a retention incentive to entice military aviators in critical aviation specialties to remain on active duty.

September 11, 2001, however, marked the beginning of the end of the mass exodus of military aviators. Civilian airlines quickly felt the economic effect of 9/11 as domestic air travel plummeted. Although Congress immediately passed the Stabilization Act that provided $15 billion in assistance to the airline industry, several major airlines were ultimately forced to reduce domestic flights and conduct mass layoffs in an unsuccessful attempt to remain profitable (Congressional Research Service, 2002). While airline jobs had become scarce, Marine Corps aviators were still able to sign new ACP contracts with annual bonus payments as high as $25,000 per year (U.S. Marine Corps, 2002).

B. PURPOSE AND OBJECTIVES

The purpose of this research is to investigate the viability of using an auction mechanism for assigning aviator retention bonuses. More specifically, this study will examine the feasibility of using the Quality Adjusted Discount (QUAD) auction to assign Aviation Continuation Pay. The goal is to evaluate the existing system and through simulation, coupled with economical analyses, determine the feasibility of replacing the current system of assigning the aviation retention bonus with one that incorporates the QUAD methodology.

C. RESEARCH QUESTIONS

1. Primary Question

The primary research question in this thesis is to explore the Marine Corps' potential cost savings by replacing the current Aviation Continuation Pay (ACP) system with an auction mechanism that utilizes the Quality Adjusted Discount (QUAD) methodology. Additionally, this thesis will investigate the degree to which the QUAD methodology can effectively increase the quality of marine aviators who receive ACP and are subsequently retained by the Marine Corps.

2. Secondary Question

A secondary question to be explored is how changing economic conditions, and the resulting changes in the civilian labor market, should affect ACP bonus amounts.

D. THESIS SCOPE AND METHODOLOGY

This study focuses on Marine Corps aviators who are eligible to receive aviation continuation pay. The thesis includes: (1) an analysis of the monetary compensation of both military and civilian pilots, (2) a review of auction theory and its practical applications, (3) an overview of the Quality Adjusted Discount (QUAD) model and its applicability in assigning Aviation Continuation Pay, and (4) a recommendation for cost-effectively assigning ACP.

II. MONETARY COMPENSATION OVERVIEW

A. MILITARY COMPENSATION

1. Basic Pay

Pay and allowances for uniformed service members are prescribed under Title 37 of the United States Code. Service members receive basic pay at a monthly rate that is based on their military rank and years of service. As the name implies, basic pay does not include any special pays and allowances to which a service member may also be entitled. Each year, uniform service members receive an increase in monthly basic pay that equals the percentage by which the Employment Cost Index increases from the previous year (U.S. Congress, 2002).

2. Monetary Incentives

To remain competitive with the civilian labor market, the military services provide monetary incentives, in addition to basic pay, to attract and retain service members in specific undermanned military occupational specialties (MOSs). For example, a Selective Reenlistment Bonus (SRB) is offered to enlisted members who hold a critical MOS and agree to reenlist in that MOS for at least four years. While Congress determines the maximum SRB the service Secretaries can pay, actual SRB bonuses for a given MOS are determined by the respective manpower planners based on anticipated personnel shortages. As a result, while marines possessing certain MOS/pay grade combinations were not eligible to receive a bonus during FY09, others qualified for bonuses as high as $90,000—the SRB payment cap mandated by Congress (U.S. Marine Corps, 2008). Once retention requirements are met, HQMC publishes a message notifying leaders that selective reenlistment bonuses for each respective reenlistment zone have been suspended. While marines may still reenlist, they will not be eligible to receive the SRB.

B.   MARINE CORPS AVIATION PAY AND INCENTIVES

1.   Aviation Career Incentive Pay

In the officer ranks, Aviation Career Incentive Pay (ACIP) is a monthly incentive paid to regular and reserve officers "who hold, or are in training leading to, an aeronautical rating or designation and who engage and remain in aviation service on a career basis" (U.S. Congress, 2002). ACIP is paid in addition to basic pay and allowances. Set forth by Congress, ACIP amounts are determined by an aviator's years of aviation service and range from $125 per month, for aviators with less than two years of aviation service, to $840 per month, for those with between 14 and 22 years of aviation service. After 22 years, ACIP payments begin to notably decrease. According to Title 37 U.S.C., aviators are entitled to continuous monthly ACIP payments through their twelfth and eighteenth years respectively, provided they "perform the prescribed operational flying duties (including flight training but excluding proficiency flying) for eight of the first 12, and 12 of the first 18 years of the aviation service of the officer."

2.   Aviation Continuation Pay

In addition to Aviation Career Incentive Pay (ACIP), Aviation Continuation Pay (ACP) is a retention bonus paid to aviators. As explained in Marine Corps Bulletin (MCBUL) 7220, the intent of the program is to provide a proactive, long-term aviation career incentive for marine aviation officers (U.S. Marine Corps, 2008). The ACP bonus targets officers in critical aviation MOSs who are within one year of completing their initial aviation service obligation. These officers usually have between eight and eleven Years of Commissioned Service (YCS) and must decide whether to remain on active duty or separate from the military and enter the civilian labor market. By this point in an aviator's career, they have typically accumulated over one thousand flight-hours and gained a wealth of experience, desirable qualities by both military and civilian standards. As a result, the military must often compete with airlines in the civilian labor market to retain its highly trained pilots and naval flight officers.

There are two ACP bonus options based on an aviator's Years of Commissioned Service (YCS). According to MCBUL 7220 for FY09, a short-term contract is available to officers who have 24 months or more remaining to complete 13 YCS; additionally, a long-term contract is available to captains and majors who have at least 36 months or more remaining to complete 16 YCS (U.S. Marine Corps, 2008). Thus, the contract length is equal to the number of months an officer has to complete an obligated 13 or 16 YCS, respectively. Title 37 states, "The amount of a retention bonus paid under this section may not be more than $25,000 for each year covered by the written agreement to remain on active duty." Similar to the SRB paid to enlisted marines, ACP levels are assessed annually based on anticipated aviator shortages. Table 1 summarizes FY09 payment provisions for both short and long-term ACP contracts as outlined in MCBUL7220.

Table 1.   FY09 ACP Payment Provisions.

	Short-Term Contract	Long-Term Contract
(1) Fixed Wing Pilots:		
(A) 7509 (AV-8B)	$10,000 Per Annum	$20,000 Per Annum
(B) 7523 (F/A-18)	$ 7,500 Per Annum	$15,000 Per Annum
(C) 7543 (EA-6B)	$ 5,000 Per Annum	$10,000 Per Annum
(D) 7556/7 (KC-130)	$10,000 Per Annum	$20,000 Per Annum
(2) Rotary Wing/Tilt Rotor Pilots:		
(A) 7532 (MV-22)	$10,000 Per Annum	$20,000 Per Annum
(B) 7562 (CH-46)	$ 5,000 Per Annum	$10,000 Per Annum
(C) 7563 (UH-1)	$10,000 Per Annum	$20,000 Per Annum
(D) 7564/6 (CH-53)	$ 7,500 Per Annum	$15,000 Per Annum
(E) 7565 (AH-1)	$10,000 Per Annum	$20,000 Per Annum
(3) Naval Flight Officer:	$ 2,500 Per Annum	$ 5,000 Per Annum

FY09 ACP payment provisions as outlined in MCBUL7220.

Approximately 400 aviators become eligible for the ACP bonus each year, but the target number the Marine Corps must retain to fill critical aviation billets is

determined by manpower planners based on projected endstrength requirements. Typically, the target retention goal is around 200 out of the nearly 400 eligible officers. ACP bonuses are based on historical levels and the accompanying number of aviators who retained at a particular bonus level. The historical bonus amount is then increased or deceased based on current aviator demand (Davidson, 2009).

Although an aviator must be recommended by their commanding officer, ACP is essentially granted to all aviators who apply as long as they meet the requirements set forth in MCBUL 7220. The quality of aviators being retained is seldom considered, nor is there consideration for the economic rent paid to aviators with lower opportunity costs who would have retained even without the ACP bonus. Unlike the SRB program, the ACP bonus remains available to eligible aviators long after the Marine Corps has achieved its aviator retention goals. As a result, the Marine Corps retained 162 percent of the targeted aviator population in FY09. An auction mechanism could identify the level of ACP required to yield the desired endstrength requirements. Accordingly, the Marine Corps could significantly reduce the excess economic rent paid to aviators with lower opportunity costs of remaining on active duty; this could potentially save the Marine Corps millions of dollars each year in recaptured economic surplus. Figure 1 is an example of the economic rent paid by the Marine Corps in FY09.
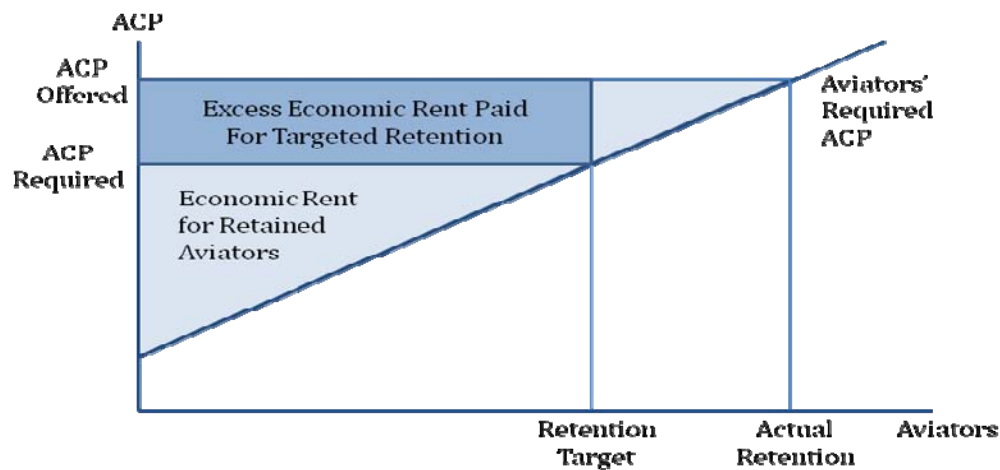
Figure 1. Economic Rent from Excessive ACP

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C.   CIVILIAN AVIATION

1.   Wages and Benefits

Civilian airline pilots have historically earned some of the highest wages in the nation. While the median annual salary in the United States was $32,000 in 2008, the Bureau of Labor Statistics reports that airline pilots, copilots, and flight engineers earned salaries ranging from $55,000 to $150,000, with a median annual salary of $111,680. Additionally, commercial pilot earnings ranged from $32,000 to $130,000, with a median annual salary of $65,340 (U.S. Department of Labor, 2009). Salaries on the higher end of the spectrum are paid to the most senior pilots; lower salaries are paid to commuter pilots and those with the least seniority. In addition to higher than average annual wages, civilian pilots are also afforded benefits including expense allowances, per diem, and free airline travel for the pilot and their immediate family. Although civilian pilots earn higher than average annual wages, the annual basic pay, benefits, and incentives paid to military aviators can be quite comparable. Figure 2 compares the estimated median annual monetary wages of civilian and military aviators.

Pilot Pay Comparison
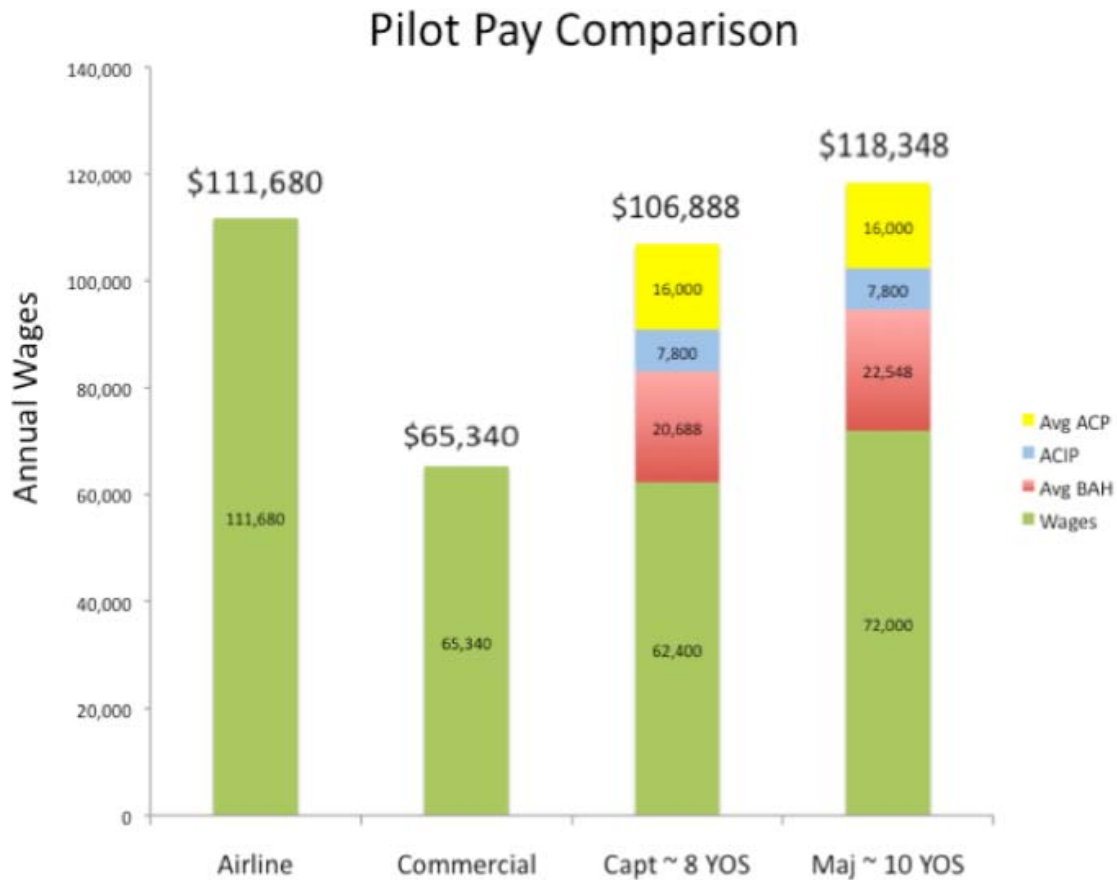
Note: Average BAH is an annual amount based on 2009 BAH rates for North Carolina and California based aviators. Average ACP represents an annual amount for an aviator on a long-term ACP contract during FY09.

Figure 2.   Military and civilian pilot pay comparison.

2.   Economic Conditions

Pilot employment is sensitive to cyclical swings in the economy. During recessions, when the demand for air travel decreases, airlines are often forced to ground planes, reduce the number of flights, and even lay off some pilots (U.S. Department of Labor, 2009). According to the National Bureau of Economic Research, December 2007 marked the start of the current economic recession (National Bureau of Economic Research, 2009). In the 23 months spanning from December 2007 through October 2009, the Bureau of Labor Statistics reports that nearly 50,000 mass layoffs had occurred, leading to over 5,000,000 layoffs

in the United States; meanwhile, the national unemployment rate climbed from 4.9 to 10.2 percent (U.S. Department of Labor, 2009). As fuel costs reached record levels, United Airlines became the first major airline to slash cockpit jobs. To further reduce operating costs, United Airlines laid off 950 of its 6500 pilots (The New York Times, 2008). U.S. Airways would soon follow, laying off over 300 of its 5000 pilots (U.S. Airways Group, 2009).

Although layoffs have plagued the civilian labor market since the current recession began in 2007, uniform service members have enjoyed a relatively secure employment outlook. In fact, the Army and the Marine Corps increased their total end-strength during the economic downturn. In 2007, the President approved a combined increase of 92,000 active duty personnel for the two services: the Army gained 65,000 additional soldiers, while the Marine Corps increased its ranks by 27,000 (Department of Defense, 2007). Subsequently in 2009, the U.S. Senate granted the Army permission to temporarily increase its ranks by as many 30,000 additional soldiers. In total, the personnel gains represent end-strength increases of nearly 20 percent for the Army and 15 percent for the Marine Corps.

D. SUMMARY

This chapter outlines the compensation and benefits of military and civilian aviators and compares the estimated pay of the two. The chapter also discusses economic conditions and the effect the current recession has had on both the military and civilian labor markets. At a time when civilian unemployment exceeded 10 percent, the Army and Marine Corps increased total endstrength by 122,000 personnel. Moreover, while two major airlines furloughed 1250 total pilots, the Marine Corps retained 127 aviators beyond its FY09 retention target of 203 aviators. As each ACP eligible aviator received an average ACP bonus of $16,000 in FY09, the total cost to the Marine Corps is over five million dollars per year; two million dollars beyond the amount required to achieve the FY09 retention goal. An auction mechanism that utilizes the QUAD methodology could

potentially save the Marine Corps millions of dollars each year by enabling manpower planners to (1) achieve the target number of aviators, (2) reduce the economic rent paid to aviators, and (3) increase the overall quality of aviators retained by the Marine Corps.

III. INTRODUCTION TO AUCTION THEORY

A. BACKGROUND

An auction is defined as a market institution with an explicit set of rules determining resource allocation and prices on the basis of bids from market participants (McAfee & McMillan, 1987). The earliest recorded auctions are believed to have occurred in Babylon around 500 B.C. During that time, "women of marriageable age were sold annually to buyers on condition that they be wed. Competitive bidding established premium prices for the more attractive maidens and lower prices for the less attractive ones" (Cassady, 1968). Today, auctions are still a popular way to negotiate prices for goods and services that may not have a standard value or whose value fluctuates with current supply and demand conditions (McAfee & McMillan, 1987). Such items include, but are not limited to, antiques, artwork, livestock, U.S. Treasury bills, and manufacturers vying for government contracts.

B. VOCABULARY OF AUCTIONS

To facilitate ease of reading, this section briefly summarizes the auction terminology most frequently used within this study. The following section consists of a compilation of theses conducted at The Naval Postgraduate School. All information is used courtesy of the following Thesis authors: William N. Filip, Paul B. Bock, and Tony K. Verenna.

Although auctions can vary significantly based on location, rules, or format, there are certain terms that are constant throughout any auction. For instance, in any auction there are bidders and bid-takers. **Bidders** are the persons or entities competing against each other for the winning price. The **bid-takers** are those who receive the price offers proposed by the bidders. On the other hand, there are sellers and buyers. A **seller** is one who has a good or service that he or she is willing to provide at the right price. The **buyer**, however, is the one looking to purchase the good or service from the seller.

The most commonly recognized auction is one with a single seller of a good and multiple buyers competing for the right to buy the good. This is called a **forward auction**, and is often used for selling artwork, furniture, or other individual items. For this type of auction, the winner is the bidder willing to pay the seller the highest price for the item. However, there exists a case with one buyer in search of a good or service with multiple sellers vying for the right to provide the service. This type of auction is called a **reverse auction**, and is commonly used by governments for contracting services to build weapon systems, erect buildings, and create labor contracts. In this situation, the winner is the bidder willing to sell the good or perform the service at the lowest cost to the buyer.

During an auction, bidders' valuation of an item is reflected by their **reservation price**. The Reservation price is the maximum amount a bidding buyer is willing to pay for an item in a forward auction, or the minimum amount a bidding seller would accept in a reverse auction. Alternatively, bid-takers often use a **reserve price** to ensure adequate/sufficient rent is exchanged in the transaction. A reserve price is the minimum a bid-taking seller is willing to accept for an item in a forward auction, or the maximum a bid-taking buyer is willing to pay in a reverse auction.

For a detailed explanation of auction theory and the various auction types and their application, refer to the Appendix.

IV. QUALITY ADJUSTED DISCOUNT (QUAD) MODEL

The QUAD model operates under the principles of a Second-Price Sealed Bid Auction in that buyers submit a single, sealed bid and the good is awarded to the bidder who submits the highest bid. The winning bidder then pays a price equal not to his own bid, but to the second highest, or first excluded, bid (McAfee & McMillan, 1987). In a Second-Price sealed Bid auction, the dominant strategy is for all buyers to bid their true reservation price

However the QUAD model differs slightly in that it is a reverse auction; thus, it consists of a single buyer, buying the services of multiple sellers. The winning sellers are those who submit the lowest bids. The buyer then pays the winning sellers a price equal to the first excluded bid. As mentioned above, the dominant strategy in a Second-Price sealed Bid auction is for all buyers to bid their true reservation price.

A. SELLERS

Marine aviators represent the sellers; these officers are trying to maximize their total income by submitting ACP bids, b_i, to the Marine Corps for their retention and continued service as an aviator. The bid amounts represent each officer's reservation value, r_i, for remaining on active duty. All bids are sealed; thus, officers are not able to observe their rival's bids, nor can they adjust their own bid, once submitted. There is no incentive to exaggerate one's reservation price by submitting an inflated bid, because officers will not be retained if their bid is rejected. Additionally, there is no incentive to underbid one's reservation price because you may be retained at an unacceptable price

B. BUYERS

Marine Corps Manpower Planners represent the buyer. The Manpower Planners' objective is to curtail anticipated aviator shortages each year by purchasing the continued service of officers in critically short aviation MOSs.

Because this is a reverse auction, Manpower Planners will purchase ACP bids from officers who are willing to provide their services for the smallest ACP bonus. The Marine Corps will also attempt to retain higher quality aviation officers by utilizing the QUAD framework outlined below.

C.   CONCEPTUAL FRAMEWORK

The primary difference between the QUAD model and a standard second-price sealed bid reverse auction is that the QUAD model controls for quality by providing a monetary discount to the ACP bids of aviators with higher quality ratings. Officers with a Quality rating of q^* or greater will have their bids reduced by A to compensate for their presumably higher reservation value. The bids of officers who do not have the desired quality rating will remain unchanged.

1.   Process

Bidders (military officers in our example) will be characterized by 3 values: b_i, q_i and r_i, representing bid, quality and reservation value, respectively. There are total of N_i agents. Agent i's goal is to maximize his payoff, p_i, by submitting bid b_i. Reservation value, r_i, is private information and quality, q_i, is public information. The buyer's (manpower planners in our example) objective is to retain M many officers. In an effort to maintain higher quality officers, assume the Department of the Navy (DoN) has authorized Manpower Planners to offer an assistance of A for every officer with quality rating above q_i^*.

After receiving all ACP bids, USMC Manpower Planners will calculate the Quality Adjusted Bid, b_i^* as follows:

$$b_i^* = \begin{cases} b_i & \text{if } q_i < q^* \\ b_i - A & \text{if } q_i \geq q^* \end{cases}$$

Then Manpower Planners rank b_i^* from lowest to highest and accept the M bidders with the lowest quality adjusted bids. Denote b^* as the M+1 lowest bid (first excluded bid). Therefore, officers with a $b_i^* < b^*$ will be retained. If there is a tie, the officer with the highest q_i receives the bonus.

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Everyone who is retained will be paid an ACP bonus as follows:

$$p_i = \begin{cases} b^* & \text{if } q_i < q^* \\ b^* + A & \text{if } q_i \geq q^* \end{cases}$$

Anyone not retained will receive his or her reservation value of r_i from the outside offer.

For example, two officers each submit b_i of $10,000; *Officer A* has the required q^* quality rating, *Officer B* does not. Manpower Planners will provide a $2,000 QUAD to the bids of officers with a quality rating greater than or equal to q^*. Because *Officer A* has the desired q^* quality rating, his submitted bid would be reduced by $2,000; thus, the *quality adjusted bid, q**, of *Officer A* will be $8,000. Conversely, *Officer B* does not have the desired q^* quality rating; the *quality adjusted bid, q**, of *Officer B* would be his $10,000 submitted bid.

D.   MODEL CONSTRUCT

For the QUAD model to operate efficiently, the following guidelines must be adhered to:

- For each aviation MOS, determine the number of aviators needed for retention and conduct a reverse second-price, sealed bid, auction for ACP contracts.

- Eligible officers in each qualifying MOS submit a single, sealed bid that represents their reservation value for continued service as a marine aviator.

- Because the QUAD model represents a reverse auction, the winning bidders will be the officers who submit the lowest bids.

- Once all bids are received, manpower planners will apply a Quality Adjusted Discount (QUAD) of *$A* to the bids of officers with a quality rating of q^* or greater.

- The cutoff amount, or ACP bonus paid to all aviators with a winning bid, will be the first excluded bid of each auction (i.e. the lowest losing bid).

- Officers who submit a winning bid, and whose quality rating is equal to q^*, will receive an ACP bonus equal to the cutoff amount, plus the amount of their respective QUAD.

- Participation in the QUAD auction represents a binding ACP contract for all officers who submit winning bids.

- The Marine Corps will not retain officers whose bids are rejected.

E.   KEY POINTS AND ASSUMPTIONS

In order to estimate the Marine Corps' potential cost savings and quality gains by replacing the current ACP system with one that utilizes the QUAD model, the following assumption were applied to the analysis:

- Because over 95 percent of aviators opted for the long-term ACP contract in FY09, this study will not distinction between short-term and term and long-term ACP contracts.

- Aviation officers receive a quality rating from their commanding officer when applying for ACP. Quality ratings range from one to five, with five being the highest.

- There is also the assumption that there is a strong, positive correlation between quality and reservation value; thus, higher quality officers will generally have higher reservation values, resulting in higher ACP bids.

F.   BIDDING STRATEGY

Because officers are not retained if their bid is rejected, truthfully revealing one's reservation value is the optimal bidding strategy. An officer's bid should accurately reflect their reservation value for remaining on active duty. Take, for example, an employee who is trying to decide whether to work for Company A or Company B. Both companies are identical in every way and the employee has no preference for either company. Company B has offered the employee a guaranteed salary of $100,000; thus, the employee's reservation value for working for the Company A is $100,000. The employee's bid should reflect this reservation value in salary talks with Company A.

By truthfully bidding one's reservation value, the employee is able to maximize their income potential. Thus, the bidder will always receive an amount greater than, or equal to, his or her true reservation value. Table 2 illustrates the expected outcomes that result from utilizing the three possible bidding strategies:

1) Overbidding, 2) Underbidding, and 3) Truthfully bidding one's reservation value. Highlighted in green in the table below is an illustration of how truthful revelation of one's opportunity cost ensures that the bidder will always receive an amount greater than or equal to their reservation value during salary negotiations. Thus, the bidder will never lose money by bidding their true reservation value.

Table 2.   Optimal bidding strategy when an outside offer exists.

Highlighted in green, the optimal bidding strategy is truthful revelation of one's opportunity costs.

Outside Offer: $100,000	If Cutoff Bid is $95,000	If Cutoff Bid is $100,000	If Cutoff Bid is $105,000
Overbid $110,000	$100,000	$100,000	$100,000
Truthfully Bid $100,000	$100,000	$100,000	$105,000
Underbid $90,000	$95,000	$100,000	$105,000

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V.   ANALYSIS AND RESULTS

A.   BACKGROUND

To analyze the QUAD model's cost effectiveness in assigning ACP, the design characteristics and assumptions set forth in the previous section have been entered into a standard Excel spreadsheet. The QUAD model will be analyzed under varying conditions and the results compared to FY09 ACP payment provisions. The goal is to identify potential cost savings and quality gains for the Marine Corps if the current system is replaced with an auction mechanism that utilizes the QUAD model.

B.   MODEL ASSUMPTIONS

Estimating the potential cost savings and quality gains attainable by implementing an auction mechanism that utilizes the QUAD methodology requires making certain assumptions, to include the following:

- For a given MOS, the model will assume that 25 officers become eligible and agree to participate in the ACP auction each year.

- The Marine Corps will only retain 15 out of the 25 eligible officers from each MOS. This ratio approximates the target retention goal from FY09. Additionally, repeated trials have revealed that this ratio slightly underestimates the potential cost savings and quality gains associated with the QUAD model.

- Auction bids are randomly computer generated and range between $5,000 and $20,000. This range is commensurate with the range of ACP bonuses offered in FY09.

- Reservation value and quality are highly correlated. Thus, higher quality officers will have higher reservation values (bids).

- A standard contract for the model will be six years in length to resemble the average duration of a long-term ACP contract for a marine aviator.

C.   ANALYSIS OF THE MODEL

The model will be analyzed using randomly generated data based on FY09 ACP payment provisions. The cost of retaining a select number of officers

from a given aviation MOS under the current ACP system will be used as the baseline. This information will be compared to the cost of retaining the same number of officers using a standard second price auction. Then, both sets of results will be compared to the cost of retaining the same officers using the QUAD model.

1. Evaluation Measures

The primary measures used to evaluate the effectiveness of the QUAD model will be *Average Aviator Quality* and *Total ACP Paid.* As previously stated, the goal of the model is to increase the overall quality of retained aviators while reducing the total ACP paid. The variables used to achieve the measures of effectiveness have been labeled as follows:

a. *Reservation Value (Bid)*

The minimum amount of money an officer will accept to remain on active duty. This amount represents each officer's opportunity cost.

b. *Quality Rating*

A one to five rating given to all aviators upon applying for ACP.

c. *q**

The predetermined minimum quality rating an officer must possess to quality for the Quality Adjusted Discount (QUAD).

d. *QUAD Bid*

A Quality Adjusted Discount (QUAD) will be subtracted from the submitted (reservation value) bid of officers with a q^* or higher quality rating. The QUAD bid is an officer's adjusted bid after the quality discount has been applied.

e. *$A*

The monetary allowance allocated to discount the Reservation Value (Bid) of higher quality officers.

f.   Rank

Each bidders position in their respective bidding cohort.

g.   Retained

A binomial variable indicating whether or not an officer's bid has been accepted and the officer retained.

h.   Bonus Received

The amount paid to officers who submit winning bids. Generally, the Bonus Received is equal to the first excluded auction bid. However, officers with a q^*, or above, quality rating receive a bonus equal to the first excluded bid plus the allowance allotted for the quality discount.

i.   Target

The target retention goal for a given auction.

j.   Uniform Price

The cutoff price (first excluded bid) for the auction. The term Uniform Price Auction will be used to denote a second-price auction with a single buyer (the Marine Corps) and multiple sellers (aviation officers).

D.   STANDARD UNIFORM PRICE AUCTION

In FY09, the average long-term ACP bonus was $16,000 (U.S. Marine Corps, 2008). For that reason, $16,000 will be used as the baseline in calculating the potential savings associated with replacing the current system with an auction mechanism. Additionally, the following example will assume the goal is to retain 15 out of 25 officers from a given MOS. Based on these assumptions, the cost of retaining 15 aviators in FY09 would be $240,000 annually. Assuming a six-year ACP contract, it would cost the Marine Corps $1,440,000 to retain the 15 aviators, regardless of aviator quality or whether some aviators could have been retained for less money.

Conversely, the Marine Corps could attain the same retention goal using a uniform price auction. With a uniform price auction, the Marine Corps would grant ACP contracts to the 15 officers with the lowest opportunity costs for remaining on active duty as indicated by their auction bid. The 15 officers who submit winning bids are paid a uniform bonus equal to the first excluded (sixteenth) auction bid. Officers with higher reservation values would not be retained. Table 3 is an example of a uniform price auction being used to retain 15 aviators.

Table 3. Example of a Uniform Price Auction for a given aviation MOS.

Rank	Reservation Value (Bid)	Quality	Retained	Bonus Received
25	19796	5	0	0
24	19520	5	0	0
23	19437	5	0	0
22	14860	4	0	0
21	14766	4	0	0
20	14373	4	0	0
19	13375	4	0	0
18	12425	3	0	0
17	12101	4	0	0
16	11517	3	0	0
15	11154	3	1	11517
14	10741	4	1	11517
13	10396	3	1	11517
12	10159	3	1	11517
11	10025	3	1	11517
10	9353	2	1	11517
9	9097	3	1	11517
8	8674	2	1	11517
7	8105	3	1	11517
6	7967	2	1	11517
5	7961	2	1	11517
4	7160	2	1	11517
3	6990	2	1	11517
2	6642	2	1	11517
1	5647	1	1	11517
			Total ACP Paid	$172,755

Randomly generated reservation values ranging from $5,000 - $20,000 are used to denote the range of ACP contracts in FY09. This first excluded bid ($15,517) is the ACP bonus paid to all aviators.

1. Total ACP Paid

Based on the example above, using a second price auction to allocate ACP yields a substantial cost savings when compared to the current system of assigning ACP. The first excluded bid, and subsequent ACP paid to all 15 aviators with winning bids, is $11,517, far less than the $16,000 average ACP paid in FY09.

Based a potential cost savings of $4,483 per aviator, the total cost to retain the 330 aviators retained in FY09 could have been reduced by 28 percent. Table 4 depicts the potential cost savings associated with using a uniform price auction to assign ACP both annually and for the duration of an ACP contract during FY09.

ACP Cost	Current ACP System	Second Price Auction	Savings
Per Officer	$16,000	$11,517	$4,483
Per Year	$3,248,000	$2,337,951	$910,049
Per Duration	$19,488,000	$14,027,706	**$5,460,294**

Table 4.   Potential ACP cost savings using a Uniform Price Auction.

2. Average Aviator Quality

Although quality would not normally be considered in a standard second price auction, it is included in Table 3 to illustrate one of the primary assumptions that aviator quality and reservation value are highly positively correlated. As indicated in table above, aviators with higher quality ratings are assumed to have higher reservation values of remaining on active duty; this is indicated by their higher auction bids. Based on this assumption, a standard second price auction could potentially retain aviators with lower average quality ratings because of

their associated lower reservation values. However, the benefit of retaining aviators with potentially lower average quality ratings lies in the associated cost savings.

E. UNIFORM PRICE AUCTION UTILIZING QUAD METHODOLOGY

Operating under the same principles and assumptions previously outlined, the thesis will now compare the potential gains of a standard uniform price auction to the potential gains associated with an auction mechanism that utilizes a Quality Adjusted Discount (QUAD). The uniform price Quality Adjusted Discount (QUAD) Auction provides a monetary allowance of *$A* to the bids of all officers with quality ratings greater than or equal to *q**. For the following example, *$A* will equate to 3,000 and officers must possess a *q** rating of at least four to qualify for the allowance.

The model can potentially reduce total ACP costs, while simultaneously increasing the average overall quality of retained aviators. The total cost of ACP is reduced primarily because the QUAD reduces the value of the first excluded bid, and hence the bonus payment, to all but the highest quality aviators. To accomplish this, it is important that officers participating in the auction bid their true opportunity cost to remain on active duty. A uniform price auction accomplishes this in part because officers whose bids are rejected are not retained.

The QUAD model increases average aviator quality by discounting the bids of higher quality officers who would have been separated by a standard second price auction because of their higher opportunity costs. Under the QUAD, these higher quality aviators receive higher ACP bonuses than the uniform price paid to other aviators in exchange for their continued military service.

Table 5 provides an example of a uniform price QUAD Auction that incorporates a QUAD equal to $3,000 for quality ratings four and five. As illustrated in Table 5, the ACP decreases from $11,517 in the previous example

to $10,396 for 12 of the 15 aviators retained; it increases to $13,396 for just the three *quality 4* aviators retained in this example.

Table 5.   Sample Uniform Price QUAD Auction when *$A* = 3,000

Bidder ID	Reservation Value (Bid)	Quality Rating	QUAD Bid	QUAD Rank	QUAD Retained	Bonus Received
1	19796	5	16796	25	0	0
2	19520	5	16520	24	0	0
3	16437	5	13437	23	0	0
4	14860	4	11860	21	0	0
5	14766	4	11766	20	0	0
6	14373	4	11373	18	0	0
7	13375	4	10375	15	1	13396
8	12425	3	12425	22	0	0
9	12101	4	9101	11	1	13396
10	11517	3	11517	19	0	0
11	11154	3	11154	17	0	0
12	10741	4	7741	5	1	13396
13	10396	3	10396	16	0	0
14	10159	3	10159	14	1	10396
15	10025	3	10025	13	1	10396
16	9353	2	9353	12	1	10396
17	9097	3	9097	10	1	10396
18	8674	2	8674	9	1	10396
19	8105	3	8105	8	1	10396
20	7967	2	7967	7	1	10396
21	7961	2	7961	6	1	10396
22	7160	2	7160	4	1	10396
23	6990	2	6990	3	1	10396
24	6642	2	6642	2	1	10396
25	5647	1	5647	1	1	10396
					Total ACP Paid	$164,940

A	q*	Target	Uniform Price
$3,000	4	15	$10,396

q* = Minimum quality to qualify for QUAD (quality adjusted discount)
A = Assitance value received for QUAD
Target = Target retention goal

1. Cost Savings and Quality Gains When $A = 3,000

Compared to a standard uniform price auction shown in Table 3, the uniform price QUAD Auction has consistently proven to increase the average quality of the retained aviators. As the value of $A increases, aviator quality increases accordingly. For example, the average quality of the retained aviators in the standard uniform price auction is 2.47. However in a uniform price QUAD Auction, when a QUAD of $3,000 is applied to the ACP bids of officers with a q^* rating of four and above, average aviator quality increases from 2.47 to 2.60.

Additionally, the uniform price QUAD Auction can significantly reduce total ACP costs compared to a standard uniform price auction. However, actual cost savings from the uniform price QUAD Auction vary depending on several factors: 1) the number of bidders, 2) the actual bid amounts, and 3) the value of $A being offered. For example, the uniform price QUAD Auction produced an ACP savings of $7,815, in addition to aviator quality gains, when $A equaled 3,000. Table 6 provides a sample comparison of the quality gains and cost savings resulting from using a uniform price Quality Adjusted Discount Auction with a QUAD of $3,000.

Table 6.   Quality gains and cost savings from the Uniform Price QUAD Auction when $A = 3,000

	Uniform Price QUAD Auction		Standard Uniform Price Auction	Savings
Total ACP	$164,940	<	$172,755	$7,815
Avg Quality	2.60	>	2.47	0.13

2. Cost Savings and Quality Gains When $A = 5,500

Incrementally increasing the value of $A would increase the average quality of the officers retained as the reservation values (bids) of additional higher quality officers are discounted below the auction's cutoff bid. For example, increasing the QUAD from $3,000 to $5,500 increases average aviator quality

from 2.60 to 2.73 by retaining two additional higher quality aviators. As the QUAD allowance increases, the QUAD model retains increasingly more higher quality officers than under the standard uniform price auction.

Offering $A in various amounts ranging from 1,000 to 5500 yielded considerable cost savings during numerous trials. After a point, cost savings decrease with increases in $A. However, the decreased savings associated with increasing $A were offset by higher average aviator quality ratings. Thus, when $A increased to 5,500, greater aviator quality gains were accompanied by a corresponding ACP savings of $4,855 compared to a standard uniform price auction. Table 7 summarizes the quality gains and cost savings resulting from a uniform price QUAD Auction that incorporates a QUAD of $5,500.

Table 7. Quality gains and cost savings from the Uniform Price QUAD Auction when $A = 5,500

	Uniform Price QUAD Auction		Standard Uniform Price Auction	Savings
Total ACP	$167,900	<	$172,755	$4,855
Avg Quality	2.73	>	2.47	0.26

3. Increasing the Target Retention Goal

The size of the target retention goal significantly affects the level of potential savings captured using the uniform price Quality Adjusted Discount auction. Increasing the retention target from 15 to 20 aviators produces considerable savings in total ACP costs. Such may be the case in aviation MOSs with historically high turnover rates and during times of economic prosperity in the civilian labor market. Although quality gains in this instance are less than those previously discussed, they are nonetheless apparent. As retention rates increase, average aviator quality increases with the standard uniform price auction, and there is less room for improvement. Holding all things

equal, Table 8 illustrates the cost savings and corresponding quality gains resulting from increasing the retention target from 15 officers to 20 officers.

Table 8.   Target Retention Goal = 20/25. $A = 5,500

	Uniform Price QUAD Auction		Standard Uniform Price Auction	Savings
Total ACP	$261,580	<	$295,320	$33,740
Avg Quality	2.95	>	2.75	0.20

a.   *Diminishing Returns to Aviator Quality*

As the value of $A gradually increases, the QUAD model eventually reaches the point of diminishing returns to aviator quality, while ACP costs continued to amass exponentially.   Based on the example, offering $A in amounts beyond 5,500 failed to provide a cost savings. In fact, 12,000 proved to be the level of $A at which additional increases in $A no longer yields accompanying increases in aviator quality.   While average aviator quality reached a peak of 3.33 at that level, the total ACP cost rose to $229,575, an increase of 75 percent over the standard uniform price auction.

F.   APPLICATION TO THE MARINE CORPS

In FY09, approximately 385 aviation officers were eligible to apply for ACP. Of the 385 eligible officers, the Marine Corps had a target retention goal of 203 total aviation officers from all MOSs. To effectively apply the QUAD model to a Marine Corps specific example, a uniform price QUAD Auction was conducted using the aforementioned population and retention parameters. Under the same basic principles and assumptions previously detailed, the model will estimate the potential gains to the Marine Corps if the current ACP system were to be replaced with an auction mechanism that utilizes a Quality Adjusted Discount (QUAD). For the following example, $A will equal 3,000 and officers must possess a minimum q^* rating of four to qualify for the QUAD.

1. Cost Savings and Quality Gains When *$A* = 3,000

Consistent with the previous examples, the uniform price QUAD Auction proves superior to the standard uniform price auction for increasing average aviator quality. The ensuing quality gains stem from meeting or exceeding the higher reservation values of the presumably higher quality officers involved. Thus, a $3,000 QUAD led to an increase in average aviator quality of 0.19 points. The increase in aviator quality is accompanied by a corresponding increase in ACP savings of $109,458 compared to a standard uniform price auction. Based on 385 randomly generated ACP bids with corresponding quality ratings, and a retention target of 203 aviators, Table 9 summarizes the cost savings and quality gains from a uniform price QUAD Auction with a QUAD of $3,000 to those of a standard uniform price auction for assigning ACP.

Table 9.   Target Retention Goal = 203/385. *$A* = 3,000

	Uniform Price QUAD Auction		Standard Uniform Price Auction	Savings
Total ACP	$2,690,521	<	$2,799,979	$109,458
Avg Quality	2.61	>	2.42	0.19

2. Cost Savings and Quality Gains When *$A* = 5,000

Predictably, increasing the QUAD increases average aviator quality. Using a $5,000 QUAD increases average aviator quality to 2.79. Depicted in Table 10, the greater aviator quality gains were accompanied by a corresponding ACP savings of $29,504 compared to a standard uniform price auction.

Table 10.   Target Retention Goal = 203/385. *$A* = 5000

	Uniform Price QUAD Auction		Standard Uniform Price Auction	Savings
Total ACP	$2,770,475	<	$2,799,979	$29,504
Avg Quality	2.79	>	2.42	0.37

3. Cost Savings and Quality Gains When *$A* = 6,000

As the level of *$A* approaches the point of diminishing returns to aviator quality, further increasing the QUAD to $6,000 increases average aviator quality to 2.91. Although slightly more costly than a standard uniform price auction, the uniform price QUAD Auction results in a total quality increase of 0.49 as depicted in Table 11.

Table 11.   Target Retention Goal = 203/385. *$A* = 6,000

	Uniform Price QUAD Auction		Standard Uniform Price Auction	Savings
Total ACP	$2,834,599	<	$2,799,979	-$34,620
Avg Quality	2.91	>	2.42	0.49

Table 10 illustrated that applying a $5,000 QUAD to the current aggregate ACP example provides a modest $29,504 in cost savings. Conversely, Table 11 showed that further increasing the QUAD to $6,000 increases ACP costs compared to the standard uniform price auction. However, the cost to retain the same 203 aviators based on FY09 ACP rates would equal approximately $3,248,000. This FY09 figure is estimated by multiplying the average ACP contract in FY09 ($16,000) by the target number of aviators (203). Thus, comparing the uniform price QUAD to the standard uniform price auction can be misleading. The standard uniform price auction captures only one primary benefit of the QUAD auction, determining the precise ACP bonus to meets the Marine Corps' specific retention target. What appears to be a net loss for the QUAD auction is essentially a cost savings of over $413,000 per year for the Marine Corps compared to the current, imprecise method for setting ACP bonuses. Figure 3 summarizes the average total costs and corresponding aviator quality levels when using an auction mechanism to allocate ACP.
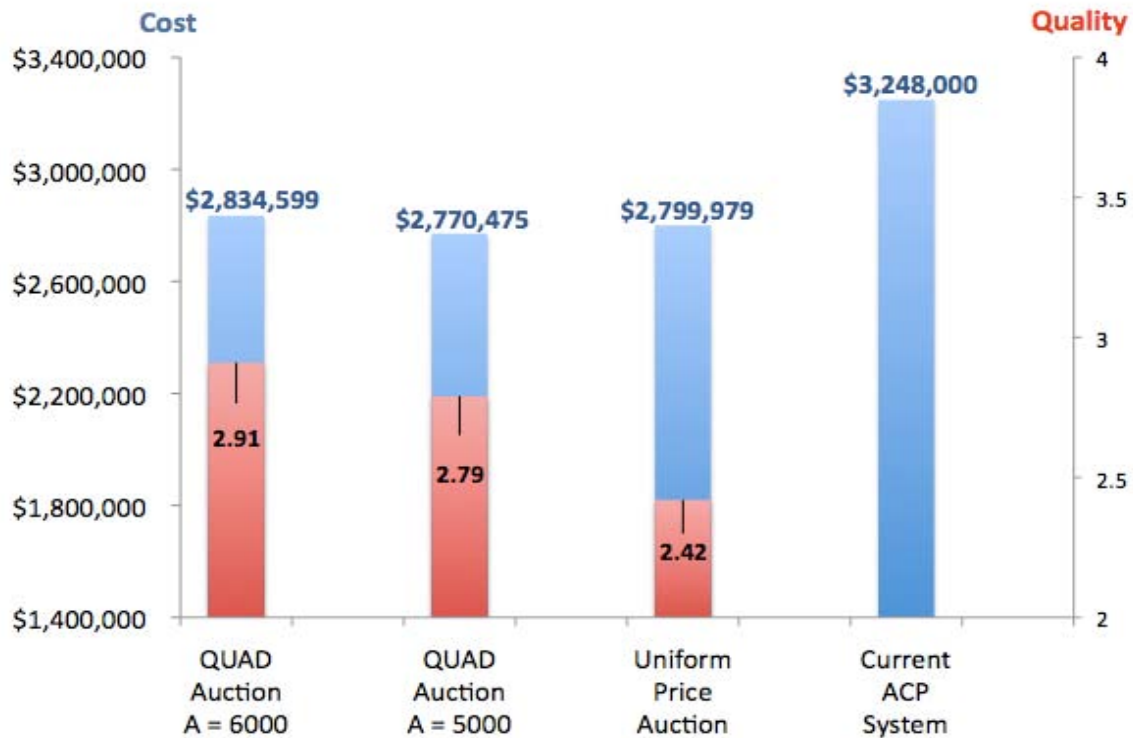
ACP Cost / Quality Comparison

Figure 3.   ACP comparison using N=385, a Target of 203 aviators and $A =
6000.

G.   SUMMARY

This section focused on the effectiveness of the model in a static environment. Although the target retention goal and the value of $A were varied for comparison purposes, the randomly generated bids and the value of q^* remained largely unchanged. Nonetheless, the QUAD model proved capable of fulfilling its predicted purpose of reducing total ACP costs while increasing the average overall quality of the retained aviators. Depending on the value of $A, the target retention goal, and the actual auction bids, the QUAD model increases aviator quality and may or may not reduce costs depending on the size of the quality discount. The modest costs savings and quality gains revealed thus far are promising indicators of the overall potential of the QUAD model under more intense analysis.

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VI. SIMULATION AND PRACTICAL APPLICATION

This section uses Monte Carlo simulation to analyze 200 bidding rounds based on Marine Corps retention goals from FY09. Certain decision variables are randomly generated. The resulting descriptive statistics can illustrate the QUAD model's effectiveness under the ever-changing and uncertain conditions typically characterizing ACP decisions.

A. SIMULATION CONSTRUCT

The simulation will operate under the procedures and assumptions previously listed. However, the following guidelines must be introduced for the QUAD simulation to operate efficiently:

- The simulation is structured upon N=385 reservation values (bids). This number represents the number of officers eligible to apply for ACP in FY09.

- The target retention goal is 203 officers, representative of the FY09 retention goal, throughout the simulation.

- The model will be used to conduct a total of 200 simulated auction rounds in order to gather sufficient data for descriptive statistics.

- All reservation values are randomly generated via computer and range from 10,000 to 20,000. This range represents the range of long-term ACP contracts distributed in FY09. Reservation values will vary for each simulated round.

- The value of *$A* will be randomly generated and range from 3,000 to 5,000. This range is consistent with the range used in static model trials. The value of *$A* will vary for each simulated round.

- The value of q^* will range from three to five and vary for each round.

- The simulation results provide descriptive statistics to analyze the potential savings associated with using the QUAD to assign ACP. The results will be compared to both a standard uniform price auction and the current ACP system.

1. Simulation Evaluation Measures

The descriptive statistics used to evaluate the simulation results are *Average Aviator Quality, Total ACP Paid,* and *Correlation.* The evaluation measures and the descriptive statistics will be generated following the 200 simulated bidding rounds. The results will compare the current ACP system to both a standard uniform price auction and to the uniform price Quality Adjusted Discount (QUAD) Auction. The descriptive statistics are defined as follows:

a. Total ACP Paid—QUAD Model

The total ACP paid using a uniform price QUAD Auction.

b. Total ACP Paid—Standard Uniform Price Auction

The total ACP paid using a standard uniform price auction.

c. Average Quality—QUAD Model

The average quality of aviators retained using the QUAD model. Average quality using the QUAD model should always be greater than or equal to the average quality using a standard uniform price auction.

d. Average Quality—Standard Uniform Price Auction

The average quality of aviators retained using a standard uniform price auction.

e. Correlation

Correlation is the degree to which reservation value and aviator quality are interrelated. Correlations can range from being perfectly uncorrelated (-1.0) to perfectly correlated (+1.0). A correlation of zero indicates that there is no relationship between the variables in question.

B. SIMULATION RESULTS

1. Static Quality Discount and Quality Level Variables

In FY09, 385 marine aviators were eligible for ACP, while the Marine Corps had a retention goal of 203 aviators. Assuming an average ACP contract of $16,000, the Marine Corps would have paid approximately $3,248,000 million that year to meet the retention goal. Consequently, the economic downturn of FY09 produced an unparalleled surge in retention as 330 officers applied for ACP. This in turn cost the Marine Corps $5,260,000 in FY09.

Based on 200 simulated bidding rounds, the model will compare the potential cost savings and quality gains associated with using the QUAD model to retain 203 aviation officers in FY09. For this simulation, $\$A = 5,000$ and the required quality to receive the QUAD is held constant at $q^* = 4$.

An important feature of the uniform price QUAD Auction is that quality will never decrease using this mechanism. In each of the 200 simulated bidding rounds, average aviator quality was greater than or equal to the average aviator quality attained using the standard uniform price auction. Of particular interest, *Aviator Quality* and *Reservation Value* maintained an average correlation of 0.71 with a standard deviation of 0.02. Additionally, the aviator quality increase resulting from the QUAD auction, as compared to the standard uniform price auction, proved significant at the 5% level. Figure 4 illustrates the average annual ACP cost, and corresponding aviator quality, resulting from the Monte Carlo simulation.
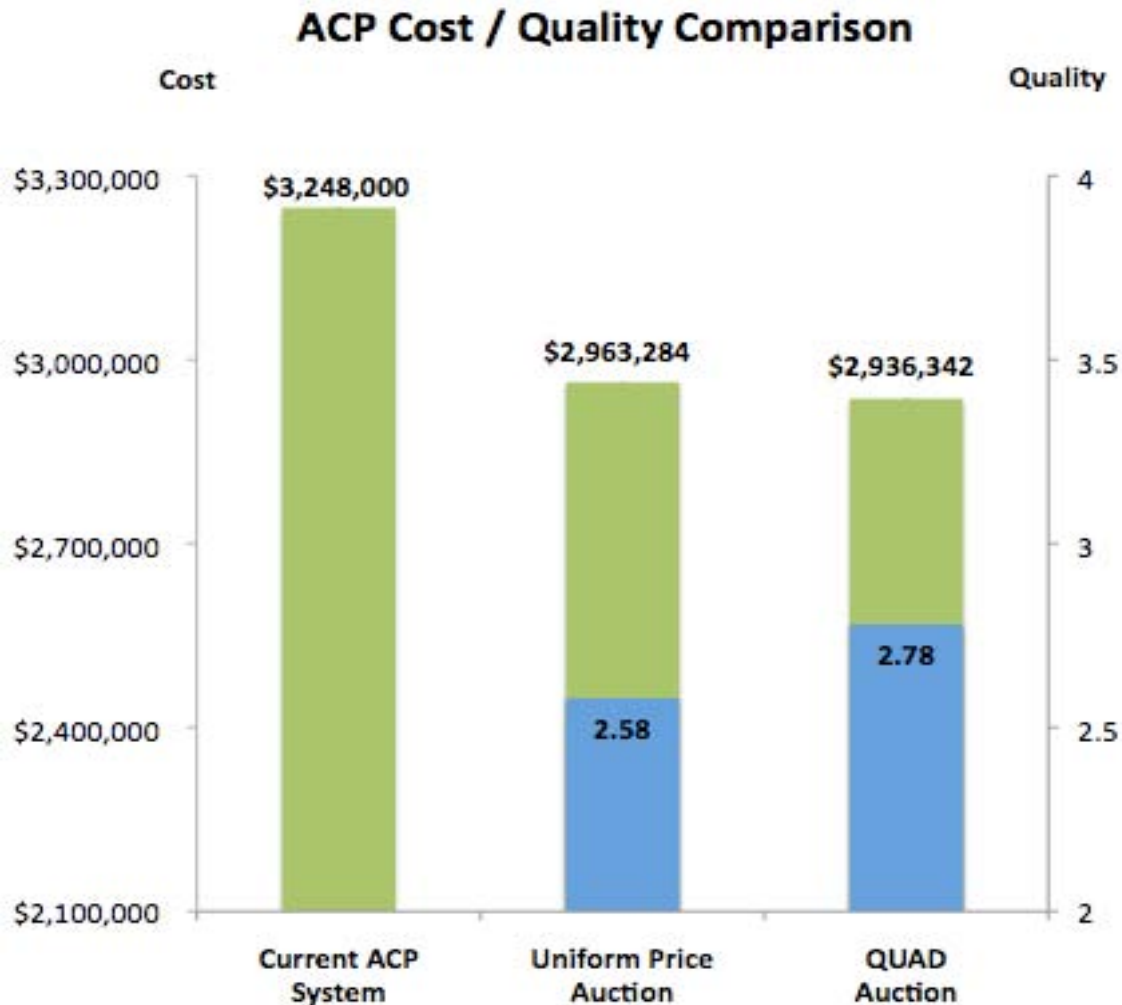
ACP Cost / Quality Comparison

The increase in average aviator quality achieved using the QUAD Auction tested significant at the 5% level.

Figure 4.   Average annual ACP cost and average aviator quality comparison when $A = 5,000$ and $q^* = 4$.

2.   Random Quality Discount and Quality Level Variables

The final ACP comparison will create an ever-changing and uncertain environment in which the independent variables are randomly generated in each of the 200 rounds. For this analysis, the value of $A varies from 3,000 to 5,000 and the level of q* required for the QUAD varies from three to five. Although the independent variables were randomly generated for this simulation, the estimated cost savings and quality increases are nonetheless similar to those achieved holding $A and q* constant. Figure 5 illustrates the quality comparison

resulting from the simulation with randomly generated independent variables estimated annual costs and the quality increases by achieving the FY09 retention goal of 203 officers when all independent variable are randomly generated.

Because quality will never decrease using QUAD methodology, average aviator quality increases in a manner similar to that achieved with A and q^* held constant. Similar to the previous comparison, *Aviator Quality* and *Reservation Values* were correlated at 0.72 with a standard deviation of 0.02. Again, the resulting increase in aviator quality proved significant at the 5% level. Figure 5 illustrates the average annual ACP costs, and corresponding aviator quality, resulting from the Monte Carlo simulation.

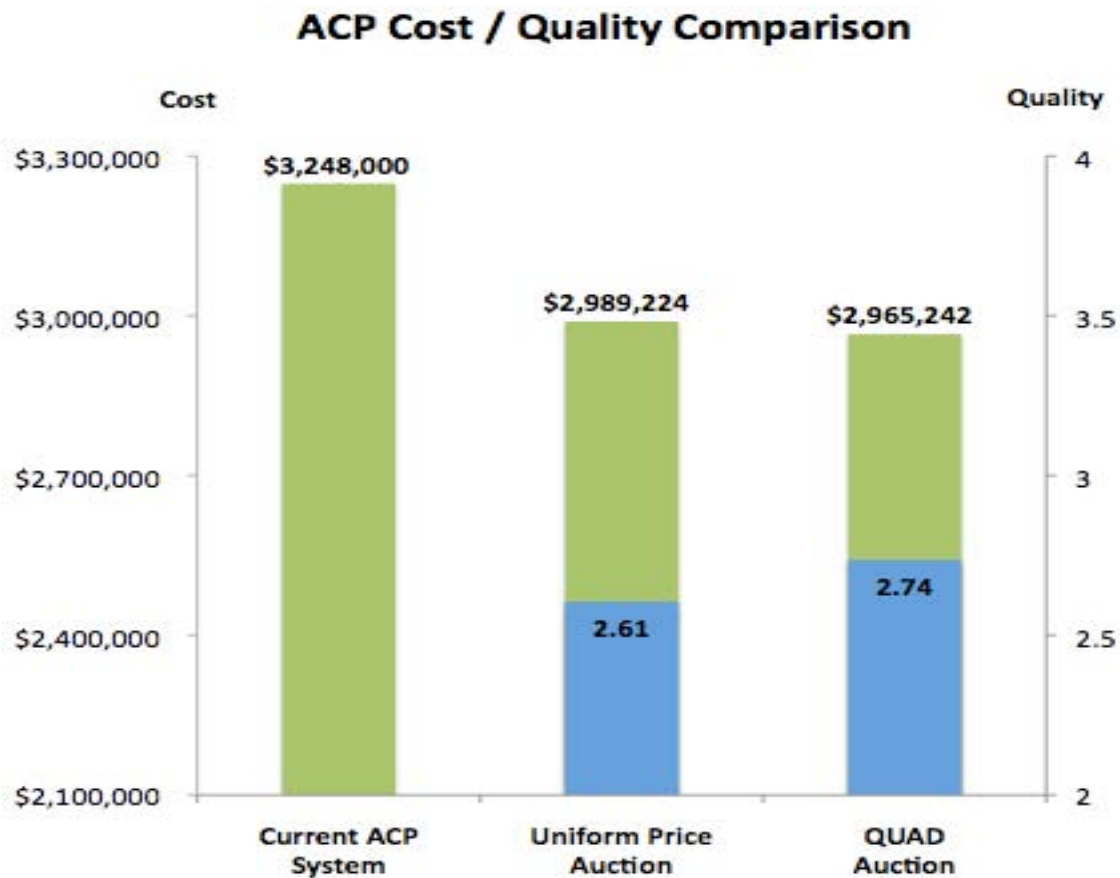The increase in average aviator quality achieved using the QUAD Auction tested significant at the 5% level.

Figure 5.   Average annual ACP cost and average aviator quality comparison when *$A* and *q** are randomly generated.

C.   SUMMARY

The Marine Corps had a target retention goal of 203 aviators in FY09. A final count revealed that some 330 aviators had been retained, a retention rate of 161 percent over the target. Such an occurrence in part reflects the harsh economic conditions that plagued the nation during the economic downturn. However, the excess retention also suggests that the ACP bonus was set too high. As a result, aviators who might not have retained initially were given a monetary incentive to do so, while aviators who would have retained for significantly less were paid in excess. Auction mechanisms can determine the precise ACP required to meet the retention target and reduce the economic rent paid to those would have retained for a smaller ACP bonus than is currently offered.

The power of an auction lies in its ability to invoke truthful revelation of reservation values. Thus, each bid represents the value of alternative employment the bidders expect in the civilian labor market if their bid were to be rejected. As a result, the ACP bonuses are set at the correct monetary amount, the amount commensurate with one's opportunity costs in the civilian labor market. If a uniform price Quality Adjusted Discount Auction were to be adapted during times of economic downturn, the modest cost savings and quality gains realized in the simulation could increase considerably as participants are faced with diminishing civilian labor market opportunities. Thus, higher quality officers could potentially be retained for significantly smaller ACP bonuses than previously offered.

VII. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. SUMMARY

The notion of using an auction mechanism to more cost effectively assign some type of military incentive pay has been the subject of several studies and theses over the past five years. However, this is the first known academic study that addresses the quality aspect of the personnel targeted for retention. This thesis explores the use of an auction mechanism to more cost effectively assign Aviation Continuation Pay (ACP) while simultaneously retaining higher quality aviators.

The objective of the study was to examine the benefits to the Marine Corps of using an auction mechanism to assign ACP. The purpose of the uniform price Quality Adjusted Discount Action is to reduce total costs, while simultaneously retaining higher quality personnel. The goal of this study was to evaluate the existing ACP system and through experimentation, coupled with economical analyses, determine the feasibility of replacing the current system of assigning the aviator retention bonus with one that incorporates the QUAD methodology.

B. CONCLUSIONS AND RECOMMENDATIONS

The conclusions for the both the primary and secondary research questions explored in the study will be addressed independently. However because the primary and secondary research questions are so closely interrelated, the recommendations for both questions can best be address simultaneously.

1. Primary Research Question

- *Can a Quality Adjusted Uniform Price Auction be used to more cost effectively incentivize aviators while concurrently retaining higher quality aviators?*

Conclusions:

- Under the current system, ACP bonus amounts are based in part on the historical retention levels achieved at a given bonus amount. This method does not take into consideration the range of opportunity costs, and accompanying reservation values, maintained by the target aviator population. Some officers may be willing to retain, but require higher bonus amounts to match outside opportunity costs. If these officers' reservation values are not met, they will be lost to the civilian labor market. Other officers may require significantly lower bonus amounts to retain because of a lack of outside offers or because of their propensity for military service. These officers collect a substantial amount of economic rent if all officers receive the same ACP amount.

- Although the standard uniform price auction can save money when used to assign ACP bonuses, it lacks the ability to control for the quality of aviators retained. Therefore, we introduced a new auction mechanism called the uniform price Quality Adjusted Discount Action, which improves the average quality of aviators retained in service compared to the uniform price auction. Furthermore, our simulations demonstrate that QUAD auction also saves cost about 75% of the rounds compared to the uniform priced auction. As revealed in the study, average aviator quality increases with total ACP costs; therefore, manpower planners reserve the ability to meet the reservation values of higher quality aviators when warranted.

2. **Secondary Research Question**

- ***How should changing economic conditions, and resulting changes in the civilian labor market, affect ACP bonus amounts?***

Conclusions:

- This current method of assigning ACP does not take into consideration various economic conditions that may affect an aviator's decision to remain on active duty. For example, an economic recession would dictate that bonus amounts be lowered, while industry expansions might necessitate that

bonuses be increased. An auction format would always incorporate the current economic conditions because aviator's bidding strategy is a function of their reservation values.

Recommendations:

- Modify the current ACP system with an auction mechanism that caters to a wide range of individual reservation values resulting from various economic conditions. Based on the results, the QUAD auction will give manpower planners the flexibility to retain higher quality aviators while potentially reducing the total cost of ACP. This combination will aid the Marine Corps in its overall retention effort.

C.   AREAS FOR FURTHER RESEARCH AND STUDY

The following recommendations for further study will advance the concept of using an auction mechanism for officer retention and ACP assignment:

- Validate the QUAD mechanism through a series of economic experiments to verify that potential bidders would behave as auction theory suggests.

- Investigate the feasibility of assigning and implementing the quality rating (q^*) used to in this study to determine which aviators received the QUAD.

- Explore the practicability of promoting and retaining officers in the aviation community as a restricted MOS. This would reduce manpower surpluses and ensure that the aviators being retained are the same aviators being promoted.

- Conduct further research regarding reasons other than money that aviators retain. Informal interviews with marine aviators during the course of this study reveal that money is not the deciding factor behind their decision to remain on active duty. This indicates the need the explore alternatives retention tools.

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APPENDIX. DETAILED EXPLANATION OF AUCTION THEORY

The following is an excerpt from a thesis written by Tony K. Verenna while attending the Naval Postgraduate School.

TYPES OF AUCTIONS

1. Ascending-bid (English Auction)

This type of auction is the most common. It involves bidders raising the price until only one buyer is left. This auction can be run three ways: 1. the seller announces prices, 2. the bidders call out their prices, or 3. bids can be submitted electronically with the best current price listed (Klemperer, 2004).

2. Descending-bid (Dutch Auction)

This type of auction is exactly the opposite of the ascending-bid auction. In this scenario, the price starts out higher than any buyer is willing to pay and lowers continuously until the first bidder is willing to accept the good at the current price (Klemperer, 2004).

3. First-price Sealed Bid

This type of auction consists of each bidder submitting their bid without the knowledge of the other bidders. In this scenario, the good goes to the bidder who has submitted the highest bid and the winner pays the price they bid (Klemperer, 2004).

4. Second-price Sealed Bid

This type is very similar to the first-price sealed bid auctions. In this scenario, the winner is still the bidder who has submitted the highest bid; however, the bidder only has to pay the price of the second highest (or first excluded) bid (Klemperer, 2004).

KEY FEATURES

1. Forward Versus Reverse

a. Forward Auction

A Forward Auction is the most common form of auctioning and one that is most familiar. It involves a single seller of a good and multiple buyers bidding for the right to purchase that good. Usually the winner of this type of auction is the bidder who submits the highest bid.

b. Reverse Auction

A reverse auction consists of one buyer and multiple sellers vying for a specific good. In a reverse auction, the winner is the bidder with the lowest bid.

2. First-price Versus Second-price Bidding Strategies

a. First-price

In a forward auction, the winning bidder pays what he bid for the item; in a reverse auction the bidder gets paid what he bid. In the forward auction, if the bidder wins the auction that is below his private-value, then he receives a profit. In a reverse auction, the bidder who wins the auction above his reserve price receives a surplus. Bidders can use information or "signals" to determine the amount they are going to bid to maximize their profit or surplus. Bidders will under bid their true valuation in a forward auction and they will bid above their true valuation in a reverse auction.

b. Second-price

In a forward auction, the winning bidder pays an amount equal to the second highest bid. In a reverse auction, the winner is paid an amount equal to the first non-winning bid. In each case, one's bid is only used to determine if he is the winner. The amount the bidder pays or gets paid depends on the bids of others. In both types of auctions, the dominant strategy is for each bidder to submit a bid equal to their true valuation of the item.

3. Common Value Versus Independent Private-Value

a. Common Value

The value of the item is common or the same for each bidder; however, bidders have different private information about what the value actually is. For example, the value of land that supposedly has oil underground will have the same value to any buyer who plans to drill the oil. Bidders may have access to different "signals" about the amount of oil located underground, so they may have different perceptions about its common value. In this case, bidders might change their estimate if they learned of another bidder's signal.

b. Independent Private-Value

The value of the item is whatever the individual bidder values the item to be. This information is private to the bidder. This does not preclude bidders from changing their bid to gain an advantage once they find out the bids of others. An example of this would encompass a contractor bidding on a job. The contractor knows what the job will likely cost him; however, he does not know what it will cost other contractors.

4. Open Versus Sealed-bid

a. Open Auctions

An open auction consists of the bidders knowing the competitions' bids. Bids can be called out by an auctioneer, the bidders can call out their bids, or a bid can be posted electronically. The key to an open auction is that bidders know what others are bidding.

b. Sealed-bid

In a sealed-bid auction, the bidder only knows his bid. All bids are submitted somewhat simultaneously as each bidder submits one bid. In this case, the bidders must estimate what other bidders may bid to maximize their chances of winning.

FACTORS WHEN DECIDNG AUCTION FORMAT

Several factors need to be considered when deciding on the type of auction to be used. The objectives may differ for each seller in different auctions. According to the Revenue Equivalence Theorem (RET), the design of the auction does not matter as each type generally yields the same revenue for the seller. The following factors should be considered when designing an auction:

1. Revenue Equivalence

According to the RET, all four types of auctions yield the same revenue on average under the following assumptions:

 - Bidders are risk neutral
 - Independent private-values assumption applies
 - Symmetric bidders (each draws from similar probability distributions)
 - Payment is based only on bids

If these four criteria are met, it does not matter which design is chosen and the expected value for each auction will be generally the same. For example, the English and second-price sealed-bid auctions will yield the same revenue as the winner pays the second highest value. In the Dutch and first-priced sealed-bid auctions, the winner will attempt to outbid his competition by the slightest value to maximize his economic rent. By meeting the four criteria described above, the RET would prove to be correct. However, most auctions will fail to meet the criteria of the RET and bidders tend to act differently within each design. Klemperer raises the issue of collusion and the attractiveness to potential bidders as reason for susceptibility. An auction designer needs to understand the purpose of the auction to design it correctly.

2. Risk Tolerance Among Bidders

Information is a key aspect in all forms of auctions. In the open form auctions, bidders can view their competitors' bids; whereas, in sealed bid auctions, the bidder is dependant on the information he has gathered to submit a bid based on his value. The amount of information or lack of information creates uncertainty and risk.

Generally, a risk neutral bidder's behavior is not affected by an increase in risk, and, therefore, such a bidder will approach all types of auctions in the same manner. On the other hand, most individuals are risk averse and will attempt to decrease their risk and increase their certainty. A risk averse person will tend to bid more aggressively to increase the probability of winning and reduce the

uncertainty. This also would decrease the surplus value received from the product if a risk-averse individual is the winning bidder. Risk averse bidders will typically generate higher values for the sellers in the Dutch and first-price sealed bid auctions compared to the English and second-price sealed bid auctions.

3. Collusion

Individual bidders would like to collude in auctions to keep prices at a minimum. In open auctions, collusion could occur through signals among bidders or through the bid itself, especially if the product is of value to the bidder. In addition, a bidder who is not cooperating with a colluder could be forced into paying a much higher price for an item than if the bidder had cooperated. In sealed-bid auctions, collusion is very rare as there is no communication between the players in the bidding process; collusion requires pre-agreement concerning the sealed bids. A seller would obviously attempt to thwart collusion, using one of the following options. First, the seller can set a reserve price (see below). Second, if the seller becomes aware that collusion is occurring, the item being auctioned can be removed and saved for another day. Third, an auctioneer could remove suspected colluders from the auction. Finally, an auctioneer could revert to unethical practices and utilize a ghost bidder to raise the price of an auction.

4. Reserve Price

For a seller to guarantee an appropriate profit, he may set a reserve price. This is a minimum price (forward auction) or maximum price (reverse auction) set at the outset to guarantee minimum revenue or maximum cost. These prices must be set carefully so they don't discourage potential bidders from bidding. For example, in a forward auction a seller could set a reserve price of $500 for an item when a bidder values that item to be $400. As a result, this potential bidder would not participate in this auction. If this reserve price scares off all potential bidders, the seller would lose his sale even though he could have potentially received his value through the auction.

Setting reserve prices could also deter collusion. If the seller sets his price to receive a profit, he will get bids assuming the price is not too high. It would not matter if colluders minimized the value or the bids; the seller would still receive some profits. Overall, setting a reserve price would reduce the incentive for bidders to cooperate.

5. Private Information

As stated previously, information is a key aspect to an auction. Information would include knowledge of the product or service, quantity available, historical sales, or competition involved. The value of an item to an individual could differ depending on how much he knows about that item. Auctioneers tend to provide information that would increase the bids to increase revenue. On the other hand,

certain information may cause bidders to revise their bids downward. An auctioneer or seller must decide what and how much information to divulge to the bidder.

Information can also increase uncertainty. If a seller releases certain information that may cause a bidder to increase his value of an item, then the risk averse bidder would increase his bid to increase his probability of winning the item.

6. Number of Bidders
An increase in competition or the number of bidders usually increases the seller's revenue. In this case, it would be to the seller's benefit to increase participation in an auction. This could also serve the purpose of a reserve price. In Dutch and first-price sealed bid auctions, more bidders tend to generate higher bids for an item as increased competition (uncertainty) and risk aversion cause participants to alter their bids; whereas increased competition in an English or second-price sealed bid auction would not change the bidding strategy, as the bidder only bids his value of an item regardless of the competition (however, the highest and second highest valued bids are likely to increase with increased participation).

7. Other Factors
Auction design can be influenced by other factors. These include: entry fees to participate in an auction, time limits instilled for the auction, and a middleman representing the bidder.

Entry fees could be charged to participate in an auction. This could separate those undesirable bidders from the more serious bidders. In addition, an entry fee resembles a reserve price, as those with low valuations of an item would be excluded. One drawback to an entry fee, especially in an assignment or bonus setting, would be that individual bidders would tire of submitting bids if it becomes non-refundable and the guarantee of return dwindles.

Time limits would control the amount of information that individual bidders could collect on other bidders to determine their value of an item or a competitor's bidding strategy. Time limits would also increase uncertainty. As stated previously, a risk averse participant would bid more aggressively to decrease uncertainty. A tight time limit imposed on an assignment or bonus auction for the military would not necessarily be suitable. Military personnel are dispersed throughout the world and information on auctions and ways to submit bids may not always be available in a timely manner.

The last factor to consider is that of the middleman. A middleman could represent the bidder. To do this, the middleman must know the bidder's valuation and must definitely know the bidder's maximum bid in a forward auction

and the minimum bid in a reverse auction. Also, it would be in the best interest of both the seller and the bidder for the middleman to know some information about the item up for bid. A positive aspect of the middleman includes the fact that military personnel could still participate in an auction no matter what their geographical or technological status, assuming they understand the previous issues.

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